Gage Measures Total Radiation, Including Vacuum UV, from Ionized High-Temperature Gases

A transient-heat transfer gage has been developed to measure the total radiation intensity from vacuum ultraviolet (below 1200 angstroms) and ionized high-temperature gases. Available metal thin-film or pyroelectric gages cannot be used for such measurements. The surface of the thin-film gage is shorted, and the surface electrodes of the pyroelectric gage are penetrated by vacuum ultraviolet photons, causing noise and depolarization of the sensor crystal.

The new transient-heat transfer gage is of rugged construction and includes a sensitive piezoelectric crystal that is completely isolated from any ionized flow and vacuum ultraviolet irradiation. The main advantage of the gage is its ability to provide total heat transfer data without the use of a quartz window, which would eliminate from measurement radiation below 1200 angstroms. The gage has a microsecond response time and can be repeatedly used without substantial change in its calibration constant. It is much simpler to construct, as it incorporates a thermally thick metal disc rather than molecular-thickness metal films which are difficult to deposit. The gage operates by sensing thermally induced mechanical stress waves which travel through the disc 500 times faster than thermal waves.

As shown in the figure, the gage includes a thermally thick silver disc having a radiant energy-receiving aluminum black coating on its exterior surface and a strain-sensing piezoelectric crystal bonded to its inner surface by a soldered connection. The bottom electrode face of the crystal is soldered to an electric lead. The upper electrode face of

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the crystal is connected through the silver disc and
the gage housing to ground. The electrodes are elec-
trically insulated and the structure is given mechani-
cal rigidity by a potting compound, which also bonds
the gage elements together.

Surface heating due to radiation absorbed on the
aluminum black coating produces a thermally induced
strain on the silver disc. This strain, a radial expan-
sion of the silver disc, is proportional to the heat flux
and is transmitted rapidly to the piezoelectric crystal.
The polarization vector of the crystal is normal to the
strain direction, resulting in an electrical charge pro-
portional to the heat flux being developed between
the crystal electrode faces. The electrical output from
the gage is delivered to a voltage recorder or display
device such as an oscilloscope.

Unwanted pressure and vibration response from
plasma can be eliminated by housing the gage in a
cavity during measurement. Gages in such housings
were used to measure the total radiant intensity of air
plasma at 10,000° to 15,000°K in the reflected shock
region of a 12-inch-diameter, arc-driven shock tube. A
gage was supported in a cavity viewing the radia-
tion through a small windowless aperture located
flush with the inside wall of the shock tube. The gages
performed satisfactorily until the inflow struck the
gage surfaces and obliterated the radiative signal
by a higher rate of convective heating. The gages
were not harmed by this adverse environment. They
were used for more than 60 shots without any substanc-
tial change in their calibration constants.

Notes:
1. Additional details are given in a disclosure avail-
able from the
   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B69-10028

2. The results of experimental measurements with
the gage on the total radiant intensity from a
plane slab of stagnant hot test gas created in
the reflected shock region of a 12-inch-diameter,
arc-driven shock tube are discussed in AIAA
Paper No. 67-311, "Measurements of the Total
Radiant Intensity of Air," by A. D. Wood, H.
Hoshizaki, J. C. Andrews, and K. H. Wilson, April
17-20, 1967. Copies of the paper are available from
American Institute of Aeronautics and Astronautics.
(Price AIAA member $0.75, nonmember $1.50.)

Patent status:
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